Factors Influencing The Temporal And Spatial Variability Of The Textural Characteristics Of Event-Scale Strata On The Eel Shelf

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LONG-TERM GOALS

The overall goal of the Strataform project is to advance our understanding of the development of stratigraphic sequences on continental shelves and slopes. Part of this understanding comes from detailed measurements of the characteristics of event-scale strata that may be formed or modified during river floods or intense storms. The research described below is directed toward providing data on the grain-size characteristics of event-scale strata that can be related directly to storms or floods observed during Strataform. This information will provide a "yardstick" with which to examine older (prehistoric) sediment units in long cores with the objectives of understanding modes of deposition, strata preservation and, potentially, any long-term changes in the local climate or river discharge. Additionally, the sediment data are being used in conjunction with measurements of bottom boundary layer flows to validate and provide inputs and "ground-truth" for sediment transport and strata development models.

OBJECTIVES

Specific goals of this effort are:

1) Provide a more complete understanding of the scales of along-shore and cross-shore spatial variability associated with the sediments at several locations in the depth-zone where nearshore sands interfinger with mid-shelf muds (i.e., between about 40 and 70 meters on Eel shelf). Our grain-size data will be merged with x-radiographs and porosity data that have been collected by Strataform colleagues to describe the variability of the shallow stratigraphy on Eel shelf.

2) Carry out detailed textural analyses of storm-generated, coarse-grained layers.

3) Monitor the evolution of the record 1995 and 1997 flood layers to develop a quantitative understanding of how these event-scale strata are changed during burial. Develop flood and storm layer “signatures”.

4) Provide detailed grain-size analyses of sediments recovered in vibra-cores, piston cores and “slow-cores” in support of our research and the research of Drs. Nittrouer, Sommerfield and Borgeld. We seek a long-term perspective that can be examined in terms of controlling factors such as climate change or variations in the sediment discharge of the Eel River. When combined with time markers (e.g., 210Pb and C14), the sediment data allow budgets to be

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calculated over significant portions of the Holocene. Also, correlation with acoustic layers in high-resolution seismic profiles will be attempted.

Information from items 2 and 3 are important for the transport modeling that is being done by other components of Strataform (e.g., Dr. Wiberg). Item 4 will be directly useful in assessing the fate of sediment introduced by Eel River.

APPROACH

A large collection of sub-samples is available for various sites from February 1995 to August 1999. We have routinely collected samples of the surface (0 - 1 cm) sediment at most regional sites on the shelf and, at selected sites (e.g., the O - line stations), we have taken multiple sub-cores of box cores and also collected piston cores.

Samples are stored in a cold, moist condition to minimize change and they are analyzed using one of two size-determination methods. One method involves wet sieving the sediment through a stack of precision sieves and drying and weighing the size fractions. This method involves no pretreatment of the sediment and it was used to determine the grain-size distribution including any grain aggregates that may have been formed by the benthic fauna.

The second method uses a Coulter Counter Multisizer II electronic particle size analyzer. This instrument was purchased in 1999 and has been in operation since July 1999. The Multisizer significantly decreases the time required for sample analysis and also supports a powerful software package for data reduction and statistical analysis.

The great analysis speed and resolution provided by the Coulter Counter, along with its ability to analyze very small samples, allows us to examine core sediments at closely - spaced intervals (1 cm or less). This is important because event-scale strata are typically less than 5 cm thick on this shelf. In addition, one of our objectives is to provide detailed grain-size data to help interpret the bulk density profiles generated by the new Geotek whole-core logger.

Spatial variability of sediment properties is important to sediment transport modelers and to understanding acoustic reflections from the seafloor. Cores collected in July 1997 will be part of a statistical analysis led by Strataform investigator J. Goff.

WORK COMPLETED

In research completed prior to the start of this contract, Dr. Drake and his Strataform colleagues have: 1) examined the characteristics of flood sediments that were deposited after major floods in 1995 and 1997 (Wheatcroft et al, 1998); 2) studied the changes to those sediment units caused by physical processes and bioturbation (Drake, 1998; 1999; Drake et al., 1998); 3) provided regional-scale sediment texture information (Drake, 1999) that has been used to interpret acoustic reflectivity data and also has been used to “ground-truth” the predictions of the sediment transport modeling group (Drs. Wiberg and Harris); and, 4) examined the spatial variability shown by a collection of box core samples that were taken as a prelude to the full spatial study of July 1997 (Drake, 1997).

During the present contract period, approximately 1/3 of the 1997 spatial variability samples have been analyzed using the Coulter Counter, a fresh set of box core samples and several piston cores were

obtained aboard the R/V Thompson in August 1999, archived long cores were sub-sampled at the University of Washington in March 1999, and we have made significant progress in our analysis of the piston core samples collected in August 1999.

RESULTS

The Strataform project has produced the first comprehensive set of information on the characteristics of event-scale strata on any continental shelf (Wheatcroft et al., 1997; Drake et al, 1998; Drake, 1999; Hill et al., 1998). The benefits of this complete dataset for associated research into sediment transport and stratigraphic modeling cannot be overemphasized. Our key results, some based on earlier research, are:

- Demonstrated the ability to quantitatively inventory and, therefore, monitor the fate of *individual grain-size fractions* on the mid-shelf (Drake, 1999; Drake et al., 1998; Drake, in preparation). Temporal changes in grain-size distributions have shown that fine-grained flood sediment was not eroded by large storm waves that should have exceeded threshold stress levels on the mid-shelf. This finding has been critical to the proper modeling of across-shelf sediment transport by Drs. Wiberg and Harris.

- Initially, spatial variability of grain-size was extremely small in the 1995 flood layer, indicating deposition from a highly flocculated suspension (see also Hill et al., 1998). Subsequent monitoring showed that physical reworking and bioturbation (Drake, 1999) produced coarsening and *mass increases.*

- A part of the flood sediment temporarily accumulates on the inner shelf beneath turbid plumes and this sediment is added to the mid-shelf layer over subsequent months, coarsening the layer and producing an inverse grading. The data suggest that the inner shelf (depth < 50m) is an important site of temporary storage of fine flood sediment.

- Spatial variability (scales of 10's of meters) of grain-size increased rapidly at the surface of the 1995 flood sediment because of physical addition of sediment from the inner shelf during storms.

- Studies in progress show that sediment that has accumulated on the mid-shelf since the 1950's is significantly finer-grained than sediment deposited prior to the 1950's. Also, specific flood event layers are readily identified by their grain-size signature in the period from 1950 to 1999, but very few layers are present in the sediments deposited before 1950, even in piston cores that we estimate may extend back 500-700 years before present. We (Drs. Drake, Sommerfield and Borgeld) are attempting to understand if and why the sedimentation system on Eel shelf has changed fundamentally during the recent past, an important issue if we are to use the recent as a key to interpreting the stratigraphic column.

IMPACT/APPLICATIONS

Future impacts related to our findings are: 1) broad changes in the character of shelf sediment can occur on time scales of hours to days during and following floods and storms. Rapid response sampling *and* much more sophisticated *in situ* sampling are required to understand these changes. 2) the physical properties of the bed (e.g., texture, cohesiveness) must be known if modeling of sediment

transport is to be accurate. 3) our understanding of the stratigraphic column depends on the quality of the standards that we have. If recent systems are different because of man's activities or other factors, theseinfluences must be quantified through careful study of long cores. Strataform research has spotlighted the critical need for high-quality 50m - 100m cores on the margin.

TRANSITIONS

Event-scale strata are the building blocks of the stratigraphic column on Eel shelf. Our results are fundamental information for the modeling components of the Strataform project. Our data on flood layer modifications has been used by Drs. Harris and Wiberg, both as inputs to begin their modeling predictions but also as "ground-truth" to check their results. Based on our data, they have modified their approach to incorporate bed cohesiveness more prominently on the mid-shelf.

The speed of the Coulter Counter has allowed closely-spaced sediment analyzes in long cores to help interpret the variations detected by the Geotek core logger (Drs. Nittrouer and Sommerfield). This will be important for sorting out the question of whether recent strata on Eel shelf are representative of long-term conditions.

The studies of time and space variability have been important as a catalyst for new ideas on how to properly sample events that may last for only a few hours or days. I am sure that new in situ sampling methods will be the outcome of this work.

RELATED PROJECTS

The seabed sampling components are all interrelated and data exchanges occur frequently. The research of Drs. Wheatcroft, Borgeld, Drake and Sommerfield are especially related because of the common objectives of providing full descriptions and understanding of the strata on Eel shelf. Dr. Drake also contributes to the sediment transport modeling effort of Drs. Wiberg, Harris and Ogston; journal articles are planned that will relate the event-scale strata to the waves and currents on the shelf. Finally, the spatial variability study will involve close cooperation with Dr. Goff (UTIG).

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